2017 - [illegible] 352EE

UNIVERSITY OF TRIPOLI /FACULTY OF ENGINEERING/E.E. Dept./Fall-2016

EE352 - Machine I **First Exam** **Spring 2017** **Time allowed: 60 minutes**

Mark : 30

Student name:______________________________ **Student #:** ______________________ **Gr:**______

Show all your answers details

Q1- A 150kVA, 50-Hz transformer with 400/80 turns ratio, has a primary winding resistance of 0.45 Ω and its leakage reactance of 0.9Ω. The secondary winding resistance is 0.02Ω and its leakage reactance is 0.04 Ω. The load power factor is 0.85 lagging. If the supply voltage is 2400V and P_{core} = 1.75kW: Calculate

a. The flux required ϕ_{rms} at no-load operating condition. 1mark

b. Draw the no-load phasor diagram. 1 mark

c. If the no-load current is 3.0 A, calculate transformer shunt circuit R_C and no-load PF. 2 marks

d. Draw the equivalent circuit referred to the primary showing all values in Ohms. 1mark

e. Find the V.R. % and full-load V2 voltage value. 3 marks

f. Calculate maximum efficiency. 1 marks

g. What is the percentage change in copper loss required to reach this maximum efficiency?1 mark

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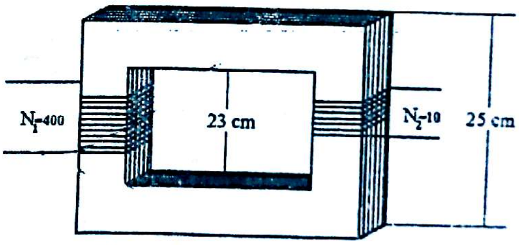
Q2. Find the all-day efficiency of 500 KVA distribution transformer whose copper loss and iron losses at full load are 4.5 kW and 3.5 kW. During a day, it is loaded as follows: 10 marks

HOURS	LOADING (kW)	POWER FACTOR
6	400	0.8
10	250	0.6
4	100	0.9
4	0	-

Q3 A square sample of iron fitted with primary and secondary winding as shown. Primary winding is 400 turns carries a current of 1.8 A on reversal of the current a change of flux linkage of 8×10^{-3} Wb-turns is recorded in the secondary windings of 10 turns.



The core is made of 50 laminations each 0.5 mm thick, assume uniform flux distribution determine the value of :

a. Flux density B in Wb/m^2. (4 Marks)

b. Magnetizing force H in AT/m. (3 Marks)

c. Relative permeability μ_r. (3 Marks)

N. M. Giali & H. M. Zubi **17/04/2017** **Good Luck**

UNIVERSITY OF TRIPOLI /FACULTY OF ENGINEERING/E.E. Dept./Fall-2016

EE352 – Machine I **First Exam** **Spring 2017** **Time allowed: 15 minutes**

Mark : 10

Student name:______________________________**Student #:** __________________________**Gr:**______

Q1 (MCQ) Mark **ONLY** one correct choice of the following: (10 marks)

1- According to **Faraday's Law** an **E.M.F** can be induced in a coil and expressed by :

(a) $\lambda\, di/dt$ (b) $L\, d\phi/dt$ (c) $N\, di/dt$ [✓ (d) $N\, d\phi/dt$]

2- According to **Lenz's Law** the **self inductance** of a coil is expressed by :

(a) $\lambda\, di/dt$ (b) $L\, d\phi/dt$ (c) $N\, di/dt$ [✓ (d) $N\, d\phi/di$]

3- The **induced voltage** on a coil due to a passing current is expressed by:

(a) $\lambda\, di/dt$ (b) $L\, d\phi/dt$ (c) $N\, di/dt$ [✓ (d) $L\, di/dt$]

4- The **nonlinear hysteresis** loop variation characteristics of an AC excited magnetic core is causing:

(a) primary windings voltage drop (b) secondary windings voltage drop

[✓ (c) eddy-current loss] (d) copper winding loss

5- In a **step-up** single-phase transformer the **induced voltage** (E) **per-turn** in Primary is:

[✓ (a) Equal to secondary] (b) Not equal (c) Greater than (d) Less than

6- 110/220 v single-phase transformer is excited with a 200 V **DC,** the secondary voltage is:

(a) 400 V (b) 100 V (c) 200 V [✓ (d) none of the answers]

7- At **no-load** operating condition the transformer has

(a) Large copper loss [✓ (b) rated voltage] (c) load current (d) lagging load PF

8- For a step up transformer **operating at full-load lagging power factor** the load voltage is:

(a) equal to rated voltage (b) more than rated voltage

(c) equal to primary voltage [✓ (d) less than at leading PF.]

9- At **half-load** operating condition the transformer typically has

(a) half rated load voltage (b) half total core loss [✓ (c) half rated secondary current] (d) half total copper loss

10- **Maximum** power transfer capability of a transformer can be achieved if

[✓ (a) core loss = copper loss] (b)core loss > copper loss

(c) core loss < copper loss (d)core loss =copper loss = zero

N. M. Giali & H. M. Zubi **17/04/2017** **Good Luck**

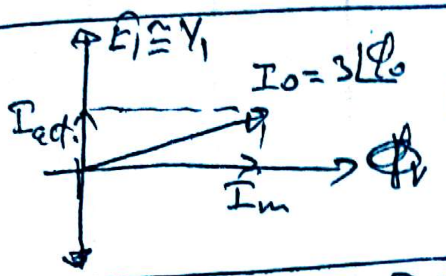
Model Answer : EE352

Q1

ⓐ $E_1 = 4.44 N_1 f \phi_{max} \Rightarrow \phi_{max} = 27^{mWb}$

$\phi_{R.M.S} = \boxed{19^{mWb}}$ ①

ⓑ

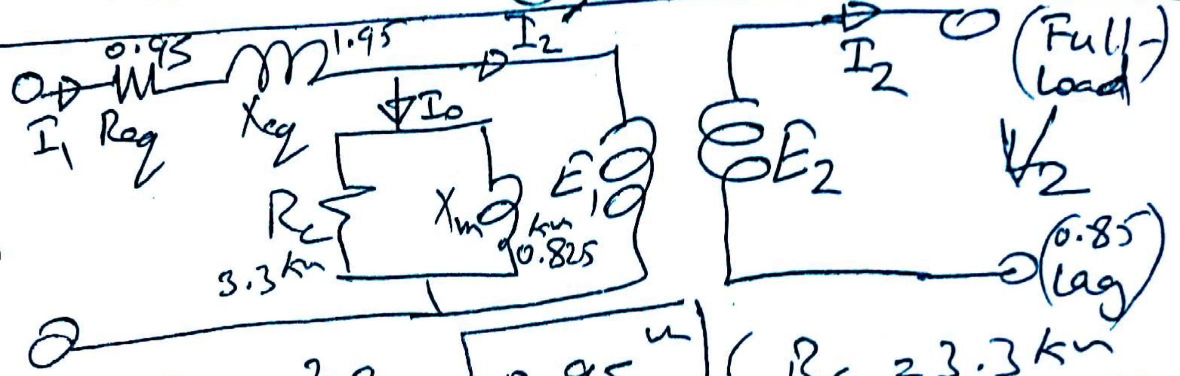


① No-load phasor diagram.

ⓒ R_c ? & P.F. No-Load ??

$R_c = V_1^2 / P_{core} = \boxed{3.3 k\Omega}$ ① & $\cos\phi_o = \frac{P_{core}}{I_o V_1} = \boxed{0.243 \text{ lag.}}$ ①

d)



①

$eq = R_1 + R_2' = R_1 + a^2 R_2 = \boxed{0.95^{\Omega}}$ ($R_c = 3.3 k\Omega$

$eq = X_1 + X_2' = X_1 + a^2 X_2 = \boxed{1.9^{\Omega}}$ $X_m = \frac{V_1^2}{Q} = 825^{\Omega}$

) $V.R.\% = \frac{I_1 (R_{eq} \cos\phi_2 + X_{eq} \sin\phi_2)}{V_1} \%$ @ lag load P.F.

$i = \frac{S}{V_1} \Big| = 62.5^A$ for P.F. = 1 @ supply-side assumption (max.)

①

$R.\% = \boxed{4.7\%}$ ② & $V_2 = 480(1 - 0.047) = \boxed{457.4^V}$

) $\eta_{max.}$? @ $P_{core} = P_{copper}$ - (variable)

@ $n = \sqrt{\frac{P_{core}}{P_{copper}}}$

$P_{core} = 1.75^{kW}$

P_{copper} for actual loading condition

$= I_1^2 R_{eq} = (\underset{(actual)}{\bar{I_2} + \bar{I_o}})^2 R_{eq} = 2873.7^{W}$

$$n = \sqrt{\frac{1750}{2874}} = 0.78$$

$$\eta_{max} = \frac{0.78 \times S\cos\phi_2}{0.78 \times S\cos\phi_2 + P_{core} + n^2 P_{copper}}$$

$$= \boxed{96.60\,\%}$$ ①

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9) To Reach η_{max}. P_{copper} should decrease from $2874^{W} \xrightarrow{to} 1750^{W}$

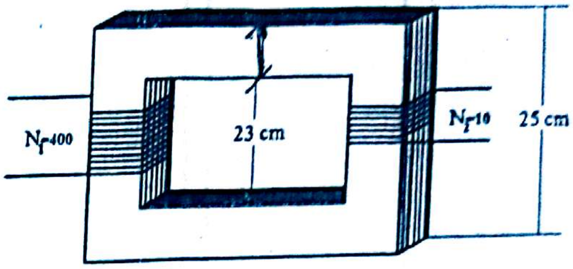
$$\Delta P_{copper} = \frac{2874 - 1750}{2874}\,\% =$$

$$\boxed{-39.1\%\ \text{decrement}}$$ ①

H	KW	KHH					KW	KWH		KWH	KWH
	Load	Energy	pf	KVA	n	n2	cu loss	E cu loss	Iron	E iron	Total E loss
6	400	2400	0.8	500.00	1.00	1.00	4.50	27.00	3.5	21	48.00
10	250	2500	0.6	416.67	0.83	0.69	3.13	31.25	3.5	35	66.25
4	100	400	0.9	111.11	0.22	0.05	0.22	0.89	3.5	14	14.89
4	0	0					0.00	0.00	3.5	14	14.00
TOTAL	OUTPUT	5300.00									
	INPUT	5443.14						59.14		84	143.1

ALL DAY	97.37%

1. A ring sample of iron fitted with primary and secondary winding as shown. Primary winding is 400 Turns carries a current of 1.8 A. on reversal of the current a change of 8×10^{-3} Wb-turns is recorded in the secondary windings of 10 turns. The core is made of 50 laminations each 0.5 mm thick assume uniform flux distribution determine the value of :



a. Flux density B in Wb/m^2. (4 Marks)

b. Magnetizing force H in AT/m. (3 Marks)

c. Relative permeability μ_r. (3 Marks)

$N_1 = 400T \qquad N_2 = 10\,T$

$I_1 = 1.8\,A$

$2\phi N_2 = 8 \times 10^{-3} \qquad \phi = 4 \times 10^{-4}$ wb

$A = \frac{(25-23)}{2} \times (50 \times 0.5) = 2.5 \times 10^{-4}\,m^2$

$l = 4\frac{(25+23)}{2} = \overset{4}{\cancel{3.14}} \times 24 = 96 \times 10^{-2}\,m$

$B = \frac{4 \times 10^{-4}}{2.5 \times 10^{-4}} = \boxed{1.6\ Wb/m^2}$

$H = \frac{NI}{l} = \frac{400 \times 1.8}{0.96} = \boxed{750\ At/m}$

$\mu_r = \frac{B}{\mu_0 H} = \frac{1.6}{4\pi \times 10^{-7} \times 750} = \boxed{1698}$

[illegible] K. H ①

UNIVERSITY OF TRIPOLI /FACULTY OF ENGINEERING/E.E. Dept./Fall-2016

EE 352 -First Exam 31-10-2016 **Time allowed: 15 minutes**

Answer **ALL** questions (12 marks)

Student name:____________________ **Student #:** ______________ **Gr:**___

Q1 (MCQ) Mark the ONLY one correct choice of the following: (6 marks)

1-In a transformer the **primary and secondary** windings are

(a) electrically connected (b) connected in series [✓ (c) magnetically connected] (d) connected in parallel

2- **Induced e.m.f.** in the primary or secondary windings in a transformer depends on

(a) transformer size [✓ (b) number of turns] (c) average flux (d) its shunt impedance

3. The full-load voltage at the transformer secondary terminals is **usually less** than its no-load value if the load power factor is: [✓ (a) lagging] (b) leading (c) ideal (d) zero

4- At **no-load** operating condition the transformer has

(a) large winding loss [✓ (b) magnetizing current] (c) output power (d) large secondary current

5- If a current of **5A** flowing in a coil of inductance **0.1 H** is reversed in **1 ms**, e.m.f. induced in it is __________ volt . (a) 5000 (b) 500 (c) 10,000 [✓ (d) 1000]

6-Transformer cores are **laminated** in order to

(a)simplify its construction (b)minimize eddy current loss (c)reduce cost (d)reduce winding loss

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Q2 (MCQ) Mark the one OR more correct choice/s of the following: (6 marks)

1 -The primary and secondary windings of a **commercial** transformer **always** have

(a) same number of turns (N1=N2) (b) same induced voltages (E1=E2)

[✓ (c) a common magnetic circuit] [✓ (d) mmf (At) balanced operation]

2- An actual **(practical)** power transformer

[✓ (a) has winding internal resistance] [✓ (b) has hysteresis losses]

(c) has no leakage flux (d) supplied by DC supply voltage

3- In an **ideal** power transformer it is assumed that,

(a) magnetic coupling factor K > 1.0 [✓ (b) 1ry & 2ry wdgs are very close]

(c) core has limited permeability [✓ (d) mutual flux ϕm = primary flux ϕp]

4-The main purpose of using a **magnetic core** in a transformer is to

[✓ (a) increase flux-linkage rate] [✓ (b) decrease the circuit reluctance]

(c) decrease its cost (d) prevent eddy current loss

5- **Mutual inductance** between two magnetically-coupled coils depends on

[✓ (a) the number of their turns] [✓ (b) permeability of the core]

[✓ (c) windings separation] (d) magnetizing current

6- The transformer load dependent efficiency **increases** from no-load to half-load at

[✓ (a) higher loads] (b) lower power factor [✓ (c) lower losses] [✓ (d) higher power outputs]

N. Giali & H. Zubi **Good Luck**

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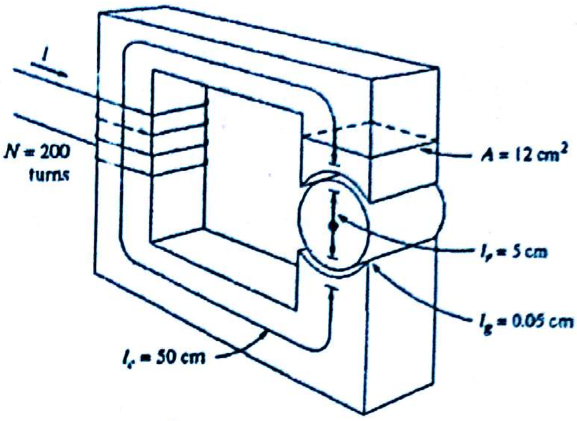
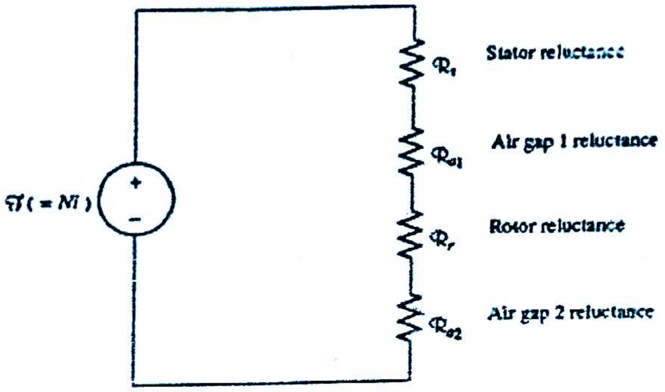
1. Figure 1. shows a simplified rotor and stator for a dc motor. The mean path length of the stator is 50 cm, and its cross-sectional area is 12 cm^2. The mean path length of the rotor is 5 cm, and its cross-sectional area also may be assumed to be 12 cm^2. Each air gap between the rotor and the stator is 0.05 cm wide, and the cross-sectional area of each air gap (including fringing) is 14 cm^2. The iron of the core has a relative permeability of 2000, and there are 200 turns of wire on the core. If the current in the wire is adjusted to be 1 A, what will the resulting flux density in the air gaps be? (8 Marks).





$$\begin{aligned}\mathcal{R}_{eq} &= \mathcal{R}_s + \mathcal{R}_{a1} + \mathcal{R}_r + \mathcal{R}_{a2} \\ &= 166{,}000 + 284{,}000 + 16{,}600 + 284{,}000 \text{ A}\cdot\text{turns/Wb} \\ &= 751{,}000 \text{ A}\cdot\text{turns/Wb}\end{aligned}$$

The net magnetomotive force applied to the core is

$$\mathcal{F} = Ni = (200 \text{ turns})(1.0 \text{ A}) = 200 \text{ A}\cdot\text{turns}$$

Therefore, the total flux in the core is

$$\begin{aligned}\phi = \frac{\mathcal{F}}{\mathcal{R}} &= \frac{200 \text{ A}\cdot\text{turns}}{751{,}000 \text{ A}\cdot\text{turns/ Wb}} \\ &= 0.00266 \text{ Wb}\end{aligned}$$

Finally, the magnetic flux density in the motor's air gap is

$$B = \frac{\phi}{A} = \frac{0.000266 \text{ Wb}}{0.0014 \text{ m}^2} = 0.19 \text{ T}$$

③

50kVA, 50-Hz supply, 2200/132 V single-phase transformer with a (16+j12.5) primary impedance and (0.025+j0.03) secondary impedance. The primary side shunt has (125 kΩ) core resistance and (j15 kΩ) magnetizing reactance. Find:

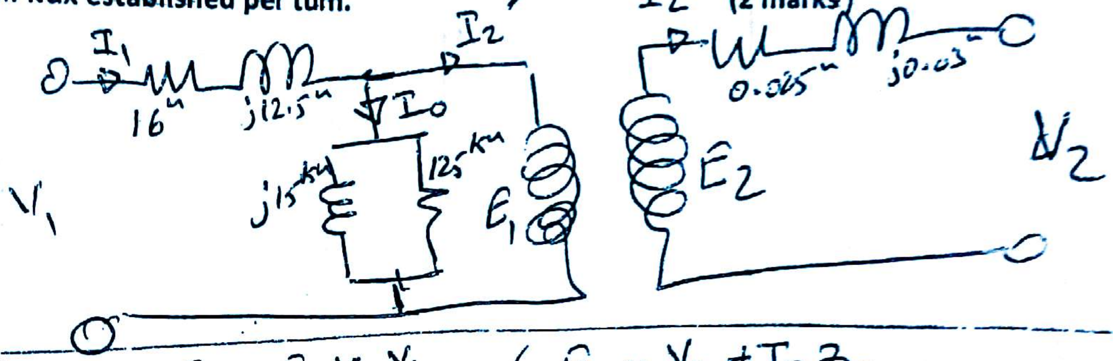
(a) The exact equivalent circuit? (2 marks)

(b) The maximum primary induced e.m.f1 for rated load at 132V and 0.85 lagging power factor. (3 marks)

(c) The supply voltage for the same operating conditions. (3 marks)

(d) The maximum flux established per turn. (2 marks)

ⓐ ②



①

ⓑ $\boxed{E_{1\,max.}\ ?}$ ⟹ $E_1 = E_2 \times \frac{V_1}{V_2}$ ($E_2 = V_2 + I_2 Z_2$

∴ $I_2 = \frac{50\,kVA}{132} \angle \cos^{-1} 0.85 = \boxed{378.78 \angle -31.79}$ A ①

$E_2 = 132\angle 0 + (378.78\angle -31.79)(0.025 + j0.03)$

$= \boxed{146.45\angle 1.87^\circ}$ V ①

$E_1 = E_2 \times \frac{2200}{132} = 2441 \angle 1.87^\circ$ V (RMS)

$|E_{1\,max.}| = \sqrt{2}\, E_{1\,RMS} = \boxed{3452\ V}$ ①

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c) V_1 ? $V_1 = E_1 + I_1 Z_1$

∴ $V_1 = 2441\angle 1.87 + (22.836\angle -32.71)(20.3\angle 38)$

$\boxed{V_1 = 2897\angle 2.8\ V}$ ①

($I_1 = I_2' + I_0$

$I_2' = I_2 / a$

$\boxed{I_2' = 22.72\angle -31.79}$ A ①

$I_0 = E_1 / (j15^k \,\|\, 125^k)$

$I_0 = 0.1634\angle -81.328$ A

Can be neglected

$I_1 = I_2' + I_0$

$\boxed{I_1 = 22.836\angle -32.27}$ A ①

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d) $\phi_{max}/turn = \frac{E_1}{4.44\, f N_1}$ ②

$= (10.96 / N_1)$ wb/t.

OR $= \left(\frac{E_2}{4.44\, f N_2}\right)$

2. A 15 kVA 2300/230 V single phase transformer is to be tested to determine its excitation branch components, its series impedances, and its voltage regulation. The following test data have been taken from the primary side of the transformer:

Open Circuit Test
V = 2300 Volt
I = 0.21 A
P = 50 W

Short Circuit Test
V = 47 Volt
I = 6.52 A
P = 160 W

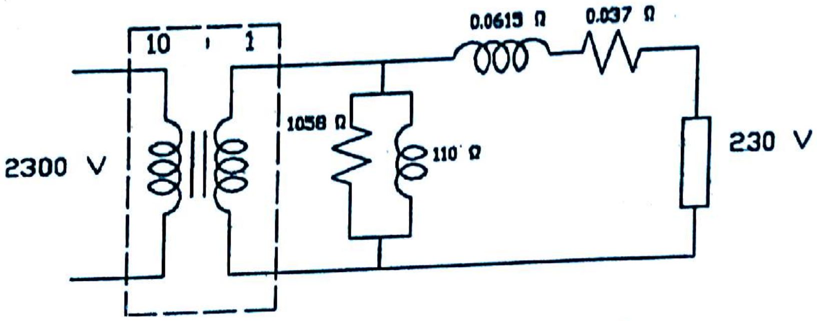
a. Draw the exact equivalent circuit showing all values of this transformer referred to low voltage side. (2)

b. Calculate the full load voltage regulation at 0.8 lagging power factor. (2)

c. Calculate the voltage at the secondary at full load. (2)

d. What is the efficiency at 60% of full load and 0.8 lagging? (2)

e. What is the maximum efficiency? (2)



$$Voltage\ \ regulation = \frac{I_1(R_{e1} \times cos(\Phi_2) + X_{e1} \times sin(\Phi_2))}{V_1}$$

$$Voltage\ \ regulation = \frac{62.5(0.0615 \times 0.8 + 0.037 \times 0.6))}{230} = 1.94\%$$

$$Voltage\ \ regulation = \frac{V_{sc}\cos(\Phi_e - \Phi_2)}{V_1} = \frac{47\cos(58.5 - 36.87)}{2300} = 1.94\%$$

$$Voltage\ \ at\ \ the\ \ sec\,ondarry = 230 - 0.0194 \times 230 = 225.54\ \ V$$

$$Efficency\ \eta = \frac{0.6\ \ \times 15000 \times 0.8}{0.6\ \ \times 15000 \times 0.8 + 50 + (0.6)^2 \times 160} \times 100 = 98.52\%$$

$$n = \sqrt{\frac{50}{160}} = 0.559$$

$$Efficency\ \eta = \frac{0.56\ \ \times 15000 \times 0.8}{0.56\ \ \times 15000 \times 0.8 + 50 + 50} \times 100 = 98.53\%$$

UNIVERSITY OF TRIPOLI / FACULTY OF ENGINEERING

Electrical and Electronic Engineering Department

Attempt All questions

EE352 ELECTRIC MACHINE I TEST #2 TIME 75 MINUTS 30 Mark

1. A 1200 kVA, 6600/400 V, Y/Y 3 phase, transformer has an iron loss of 1600 W. the maximum efficiency occurs at 0.75 full load. Find
   a. The efficiency of the transformer at full load and 0.8 power factor. 5 Marks
   b. The maximum efficiency at unity power factor. 5 Marks

$E_{rms} =$ $= N\phi$ $E = \frac{d(N\phi)}{dt}$

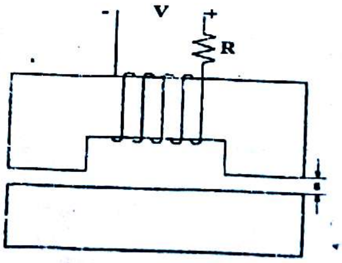
2. A 500 kVA, 50 Hz single phase 6600/5000 V autotransformer having the following values, e.m.f. per turn = 8 V, maximum flux density 1.3 Wb/m^2. Determine
   a. The core area. 3 Marks
   b. The number of turns for low voltage and high voltage sides. 3 Marks
   c. The position of the tapping point. 4 Marks

$E = N\phi_m w$

$E_{rms} = N\frac{B}{A}2\pi f$

3. As shown in the figure, an electromagnet is to be used to lift a 100-Kg slab of iron. The core cross-section area is 35cm^2 and the number of turns is 100 turns. if the supply coil resistance is 3 ohms and the minimum voltage required to lift the slab against the force of gravity is 2V. Find the resultant minimum gap in each leg in mm. 10 Marks

Neglect the reluctance of the core



2-V

$f_m \Rightarrow \frac{\partial(w_f')}{\partial x}\Big|_{i=c}$

$f_m = \int (\frac{B}{\mu_0}) * Volum$

$=$

$V = 1\Omega$

$2/3$

$\frac{Ni}{l_g} = H l_g$

GOOD LUCK

N.M.GUALI H.M.ZUBI O.G.MRIHEEL 19/12/2017

$\phi = B.A$

$e = \phi_m^c \cos wt$

$N \phi_m w$

$w_f \Rightarrow \int H dB * Volum$

$2 A l_g$

$\partial w = \int H dB$

$\frac{8.9}{5}$

9.8 m

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EE352 Final Exam Time 120 minutes Date 06/02/2018 Marks (40)

SHOW ALL ANSWERS DETAILS 10 Mars each

Q1: A single phase 20 KVA, 2400/240V transformer have the following data:

0.95

1- 98% efficiency at 90% loading and unity power factor.

2- 97.5% efficiency at full load and 0.8 lagging powr factor, Find:

a- ***Efficiency at 50% loading and 0.95 leading power factor.***

b- ***Load% at maximum efficiency & unity power factor. What will be the maximum efficiency?.***

Q2: A 2000KVA, 6.6/0.4 kV, 3 phase transformer is delta connected on the high voltage side and star connected on the low voltage side. Determine the drop on the resistance and reactance, % efficiency and %voltage regulation for full load & 0.8 leading p.f. given the following data:

6.6k 0.4k

SC Test – H.V. data: 400 V 175A 17kW

OC Test – L.V. data: 400 V 150A 15kW

Q3: A 600KVA 23kV/2.3kV Delta/Star transformer has (0.15+j0.93) impedance @ LV side is feeding a 120kVA 2.3kV/0.23kV Delta/Delta load transformer through a line that have j0.8 ohm/ph impedance. The load transformer has a (1.5+j1.8) equivalent impedance @ the HV side. If a short circuit condition occurs at the load terminals, find: a- The S.C. current in the feeder lines (I_f).

b- The S.C. current in the load terminal LV lines (I_L).

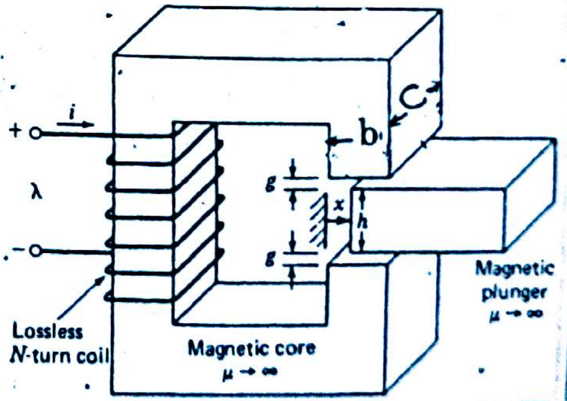
c- The S.C. current in the supply HV lines (I_S).

Q4: For the relay shown in the figure find:

a. The system inductance L(x) expression in x/b.

b. If N= 800 t , g=0.003 m , i=8A & C= 0.11 m, find the magnetic stored co-energy W'_{fld} as a function of (x/b)

c. If b= 0.16 m, Estimate the acting force (F) in N-m using **co-energy** method ONLY.



N.M. Giall **O.G.Mrlheel** **H.M.Zubi**

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EE352 -Second Exam 19-12-2016 **Time allowed: 90 minutes**

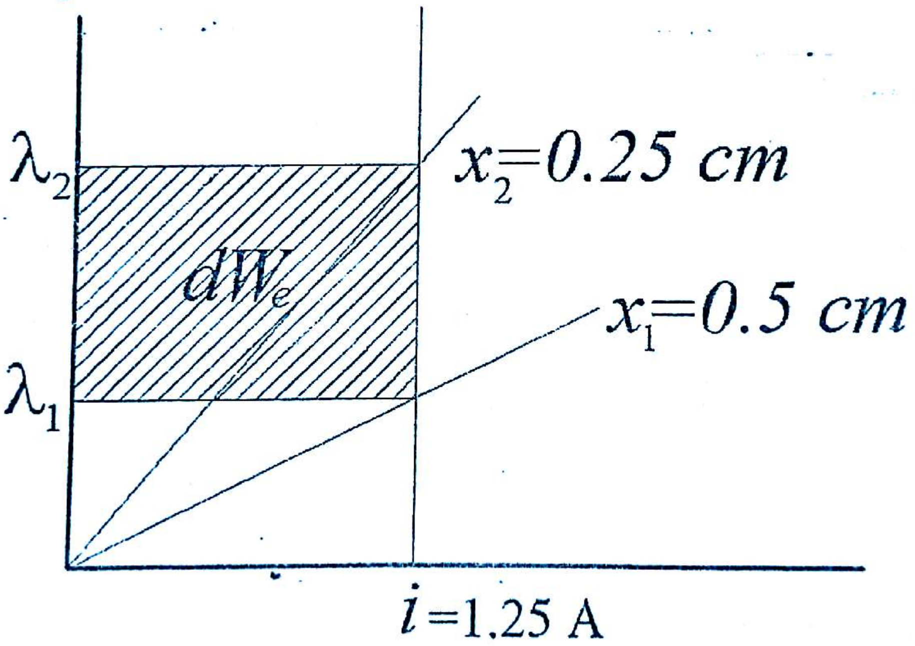
Solution

2. An electromagnetic relay has exciting coil of 800 turns. The core has a cross-sectional area of 5 cm x 5 cm. Neglect the reluctance of the core and fringing.
   a. Find the coil inductance if the air gap length is 0.5 cm. (2 Mark)
   b. Find the field energy stored for a coil current of 1.25 A. (2 Mark)
   c. Coil current remain constant at 1.25 A. find the mechanical energy output based on field energy change when the armature moves to a position for which x = 0.25 cm. Assume slow movement of armature. (3 Mark)
   d. What will be the change in the mechanical work done, if the mechanical movement is fast, keeping the flux initially constant. (3 Mark)

$$a)\ Coil\ Inductance = \frac{N^2}{\Re} = \frac{800\times800\times4\pi\times10^{-7}\times5\times5\times10^{-4}}{0.5\times10^{-2}} = 0.402\ H$$

$$b)\ The\ Field\ Energy\ Stored = \frac{1}{2}L\times i^2 = 0.5\times0.402\times(1.25)^2 = 0.314\ J$$

$$c)\ Change\ in\ Electrical\ Energy = dW_e = (\lambda_2-\lambda_1)\times i \qquad Joules$$



$$\lambda_2 = L(x_2)\times i = 0.804\times1.25 = 1.005\ \ And\ \lambda_1 = L(x_1)\times i = 0.402\times1.25 = 0.5$$

$$dW_e = (0.804-0.402)\times1.25\times1.25 = 0.628\ J$$

$$dW_f = \frac{1}{2}(L(x_2)-L(x_1))\times i^2 = 0.314\ J$$

$$dW_m = dW_e - dW_f = 0.628 - 0.314 = 0.314\ Jouled$$